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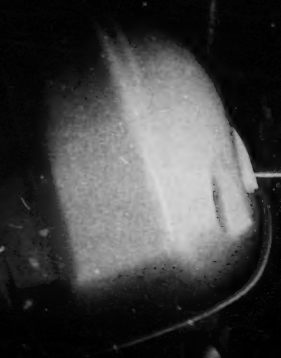
AUGUST 24, 1987

CHEMICAL & ENGINEERING

NEWS



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PLASTICS

Output will set records in 1987
Page 27

William Graham: What it's like to be Presidential Science Adviser
Page 14

CHEMICAL & ENGINEERING NEWS

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AUGUST 24, 1987

News of the Week

■ **First human testing in the U.S. of a potential AIDS vaccine to begin by October has been approved by the Food & Drug Administration.** **Page 6**

■ **Ban on plastic packaging for food that is principally targeted at polystyrene "clam shell" packages used by fast food restaurants is being considered by New York's Suffolk County.** **Page 7**

■ **National Academy of Sciences says the rigid and strict control of biotechnology products is not justified.** **Page 7**

■ **Unauthorized field tests of a genetically altered microorganism—aimed at combating Dutch elm disease—by Montana State University researcher draw widespread criticism.** **Page 8**

Business

Canadian chemical industry earnings for second-quarter 1987 register strong increase, even though sales rose only slightly, outpacing the all-industry average. **Page 11**

A $200 million investment plan for engineering thermoplastics, which will involve major production facilities for three families of polymers, has been announced by Dow Europe's plastics group. **Page 12**

Government

Presidential science adviser William Graham discusses broader context, especially national security concerns, of science and technology issues such as competitiveness and superconductivity. **Page 14**

Science

Advances in Fourier-transform techniques have greatly improved the sensitivity and resolution of microwave spectroscopy, enabling scientists to study properties of single molecules and complexes. **Page 21**

Technology

Planned guidelines for clinical lab workers will reduce risks from frequent exposure to samples from carriers of AIDS and other infectious diseases. **Page 25**

Cover: Strands of high-gloss ABS resin enter cooling bath at Dow Chemical's Midland, Mich., facility

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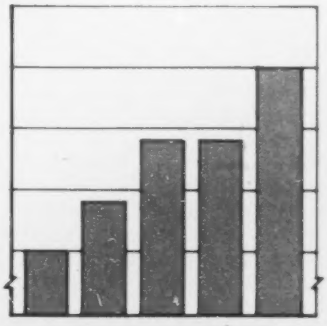

Product Report

The plastics industry is in the midst of a banner year as production and demand reach record levels, and profitability will be the best of this decade. **Page 27**

Chemical & Engineering News

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LETTERS

Superconductivity

SIR: In your report on the latest media event in the superconductor serial your editor truncated my comments to meaninglessness. C&EN has failed to provide a technically coherent perspective to all the hoopla surrounding the current superconductivity excesses. It has thereby fallen victim, although it is an international journal, to nationalist self-serving propaganda from U.S. agencies.

First, the U.S. is hardly the leading player in this game. Bednorz and Muller in Switzerland, Kitazawa and Tanaka et al. in Japan, Rao in India, and Zhao in China have made the major scientific contributions so far. Indeed the basic scientific strengths in materials chemistry and ceramic processing on which these materials were based are to be found in France and the U.S.S.R. The U.S. is, in fact, singularly weak in this field. Most of the notoriously publicized U.S. work is by physicists doing amateur chemistry. Indeed the relevant U.S. strengths in materials making, e.g., at Du Pont, General Electric, and Westinghouse, are all but ignored because they do not participate in the hype.

Neither does the work abroad have the frenetic quality we have; no rushing to the *New York Times* with half-baked data on disappearing phases. The scientific community surely has some responsibility in trying to stop the worst abuses such as reporting claims to newspapers before submitting to, or having the work accepted in a scientific journal; grossly exaggerated technical claims (as proved by subsequent events) and possible impacts on society, based on the flimsiest of data; and gross failures (which could be interpreted as willful) to refer to previous work from all over the world.

Second, to allow to pass without comment the absurdly simplistic linking by this Administration's leaders of these remarkable scientific developments directly to potential improvements in U.S. competitiveness is inexcusable exaggeration. I cannot imagine any U.S. corporation being able to even mount a serious competition to Kyocera, Toshiba, Matsushita, etc., if full-scale manufacture of major ceramic superconductor objects ever comes about. Wall Street has made it impossible for good U.S. technical corporations to maintain their long-term applied research capabilities on which industries are built. Simply giving more money to U.S. universities for superconductor research will make things worse, not better. We will produce even more research for others to use. Giving a lot more money will result in sheer waste.

Last, what the nation must be prepared for is that these new technological developments—if and when they actually lead to substantial new products—will almost certainly decrease the U.S. market share of the older technologies that may be replaced. The public really must get over the idea that the U.S. any longer has a comparative advantage in high technology. Our real hope is in the very balanced mix of technologies, which has been destroyed by similar superhype of the new at the expense of the well established. Additional federal money may be better spent in restoring the balance in our technology base rather than smothering dollars over a single already overcrowded field.

What then should the U.S. do? Make a determined effort to stop the hype. Five hundred person-years of research have not raised T_c above the 90 K of Rao, Zhao, and Wu's. It isn't going to be that easy. Every lab working in the field has seen the blips and disappearing superconductivity. Why do newspapers report them? The Penn State BHK theory may even explain some of the disappearances; let's see if the community agrees. There is no evidence as yet that there is any major commercial potential (100 NMR scanners at liquid nitrogen isn't an industry). But do start telling the President, and his agency heads, that if and when it happens, the probability of a U.S. company making reliable electronic ceramic components for the

Corrections

- June 8, page 70: In the Canadian section of the Facts & Figures for the Chemical Industry special report, the data given in the note of currency conversion are for converting $1.00 Canadian into U.S. dollars, not $1.00 U.S. into Canadian dollars. The monetary statistics in this section were converted from Canadian dollars to U.S. dollars on the basis of $1.00 U.S. equals: 1986, $1.391 Canadian; 1985, $1.362 Canadian; 1984, $1.308 Canadian; 1983, $1.244 Canadian; 1982, $1.229 Canadian.
- Aug. 10, page 28: C&EN neglected to point out that the inaccuracy in initial results reported for unemployment among ACS members during 1986 from this year's annual salary survey was first called to C&EN's attention by Nelson Marans of Silver Spring, Md.

Profits of Canadian Chemical Firms Surge in Second Quarter

Combined earnings of four major chemical firms increased 30% in the quarter and 37% in the year's first half

Profits in the Canadian chemical industry are merrily multiplying—no doubt faster than anyone dared to expect at the beginning of the year. Although most industrial sectors of the Canadian economy are enjoying a good year as far as earnings are concerned, the country's chemical industry is certainly ahead of the all-industry average.

That, at least, is what one might conclude from the combined, six-month results of the four large, publicly traded Canadian chemical companies tracked by C&EN. These companies are C-I-L, Celanese Canada, Du Pont Canada, and Union Carbide Canada.

The combined earnings of these four Canadian chemical leaders jumped a hefty 30% in the second quarter from last year's second quarter. And even though that gain paled somewhat beside the 46% profit increase they chalked up in the first quarter, it was enough to give them an overall 37% jump in profits for the first half of the year.

This first-half profit bonanza is not limited to the four major companies. Scattered results indicate that it is widespread throughout the Canadian chemical industry. For instance, the chemicals division of Canadian Occidental reported operating profits up 38% in the first six months of the year. Shell Canada Chemical turned last year's first-half loss of $10 million (all figures in U.S. currency) into a $37 million profit this year. And Esso Chemical Canada's first-half profits increased slightly despite a drop in sales.

As usual when profits surge as they have for Canadian chemical companies, a lot of factors have to fall into place at the same time. Demand for most Canadian chemicals has been strong. Prices have firmed. This is especially true of several plastics products, synthetic fibers, and chlor-alkalis. The one notable weak spot is fertilizer.

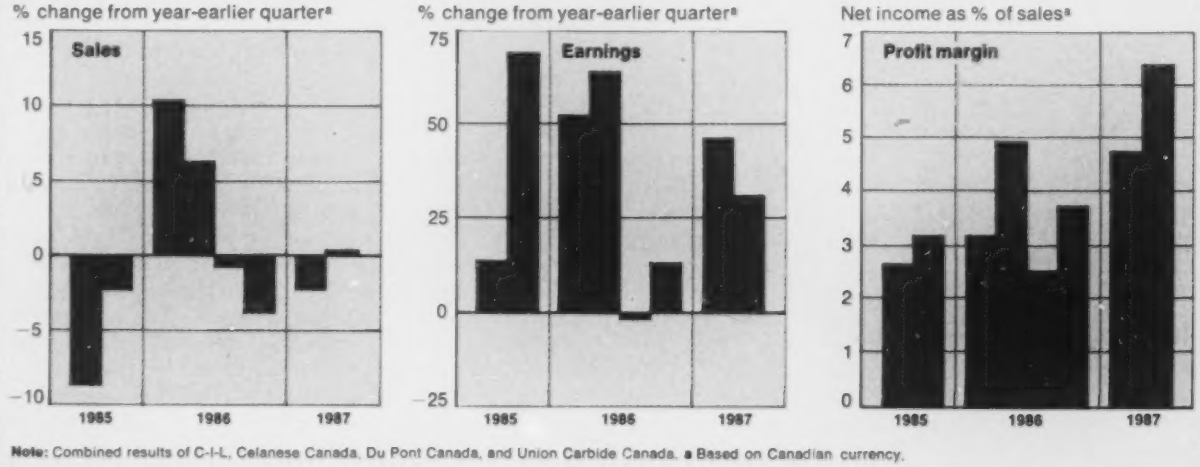
In addition, the rationalization and belt-tightening programs that many Canadian chemical firms have undertaken over the past few years are beginning to pay off. These companies really are leaner and meaner.

Modestly higher sales volumes, lower raw material costs, and improved productivity are the combination that helped Du Pont Canada chalk up the highest quarterly earnings in the company's history during the second quarter. Net income rose 33% from second-quarter 1986 to $20.8 million. That increased Du Pont's six-month profit to $38.4 million, a whopping 57.5% more than in last year's first half.

What makes Du Pont's profit performance remarkable is that it was accomplished with only a meager improvement in sales. Second-quarter and first-half sales were up only 1.2% and 2.3%, respectively.

Among other things, J. E. Newall, Du Pont Canada's president, credits

Canadian chemicals sales inch upward, but profits surge



Note: Combined results of C-I-L, Celanese Canada, Du Pont Canada, and Union Carbide Canada. a Based on Canadian currency.

For Canadian firms, earnings increase despite weak sales

$ Millions[a]	Net sales	Change from 1986[b]	Net income[c]	Change from 1986[b]	Profit margin[d] 1987	Profit margin[d] 1986
SECOND-QUARTER 1987						
C-I-L	$291.0	−1.5%	$14.3	26.7%	4.9%	3.8%
Celanese Canada	65.8	−3.7	5.3	22.8	8.0	6.3
Du Pont Canada	260.1	1.2	20.8	33.3	8.0	6.1
Union Carbide Canada	75.9	8.4	4.2	40.0	5.6	4.3
TOTAL	**$692.8**	**0.3%**	**$44.6**	**30.4%**	**6.4%**	**4.9%**
SIX-MONTHS 1987						
C-I-L	$ 504.6	−5.3%	$15.7	10.5%	3.1%	2.7%
Celanese Canada	126.2	−3.8	9.7	15.2	7.7	6.4
Du Pont Canada	499.4	2.3	38.4	57.5	7.7	5.0
Union Carbide Canada	147.1	6.2	8.9	47.5	6.0	4.3
TOTAL	**$1277.3**	**−1.1%**	**$72.7**	**37.1%**	**5.7%**	**4.1%**

a $1.00 = 1.330 Canadian dollars (second quarter) and 1.334 Canadian dollars (first half). b Based on Canadian currency. c Based on continuous operations and excluding extraordinary items. d Net income as percentage of sales.

strong fiber demand for his company's performance. And he expects this demand to continue strong throughout the rest of the year. Plastics markets also are strong, with the outlook for specialty packaging films continuing to improve.

Weak spots, Newall says, are the mining, energy, and agricultural sectors of the economy. As a result, demand slackened for explosives, pipe, and herbicides during the second quarter.

Newall also is concerned about some recent price increases in key raw materials and about a softer automotive market. He expects third-quarter results to be down seasonally from the second quarter. But the outlook for the balance of the year remains good.

W. Norman Kissick, chairman of Union Carbide Canada, says the company's profit margins were restrained in the first half "by an inability to increase prices" of many products in line with rising costs. This inability notwithstanding, Carbide Canada bumped its profits upward by 47.5% during the first half, to $8.9 million, even though sales only managed a 6.2% gain. This profit picture reflects earnings from continuing operations before extraordinary income or expenses.

After taking the market's pulse, Kissick believes that the factors that prevented Carbide Canada from matching price increases with higher costs in the first half are "correcting." This, he says, will have a positive influence on company performance during the rest of the year.

As far as profits are concerned, Celanese Canada recorded its best second quarter—and best first half—ever this year. Although sales were 3.7% lower than last year, net income rose 22.8% to $5.3 million in the second quarter. For the half, profit was 15% higher than last year's, even though sales lagged almost 4%.

Paul H. Williams, executive vice president of Celanese Canada, says that, despite lower sales volume for the textile group, income was higher because of lower raw material costs and improved efficiencies. Methanol is still a drag on company performance, but Celanese Canada has placed "sold out" signs on acetic acid, its derivatives, and cigarette filter tow for the rest of 1987.

C-I-L's six-month earnings rose a respectable 10.5% despite a 5.3% decline in sales. One of the most diversified chemical companies in Canada, C-I-L usually is among the industry's profit leaders. But continuing losses in its fertilizer operations are hurting the company this year as they did in 1986.

Still, the company scored solid gains in other areas, such as crop protection chemicals, automotive paints, and chlorine. C-I-L expects these products to perform well for the rest of the year. And an expected reduction in natural gas costs would help improve its fertilizer business.

Earl Anderson, New York

Dow Europe boosts engineering plastics

Officials of Dow Europe's plastics group last week announced a $200 million investment plan for engineering thermoplastics.

Three families of polymers will be involved—polycarbonates, acrylonitrile-butadiene-styrene (ABS), and chlorinated polyethylene thermoplastic resins. The investment will involve major production facilities for each, with 95,000 metric-tons-per-year combined capacity, and capacity for polycarbonate compounding.

First to start up will be a 20,000 metric-tons-per-year plant for chlorinated polyethylene resins at Stade, West Germany, scheduled to start up next year. According to Dow's estimates, Western European demand for chlorinated polyethylene is growing at about 10% per year.

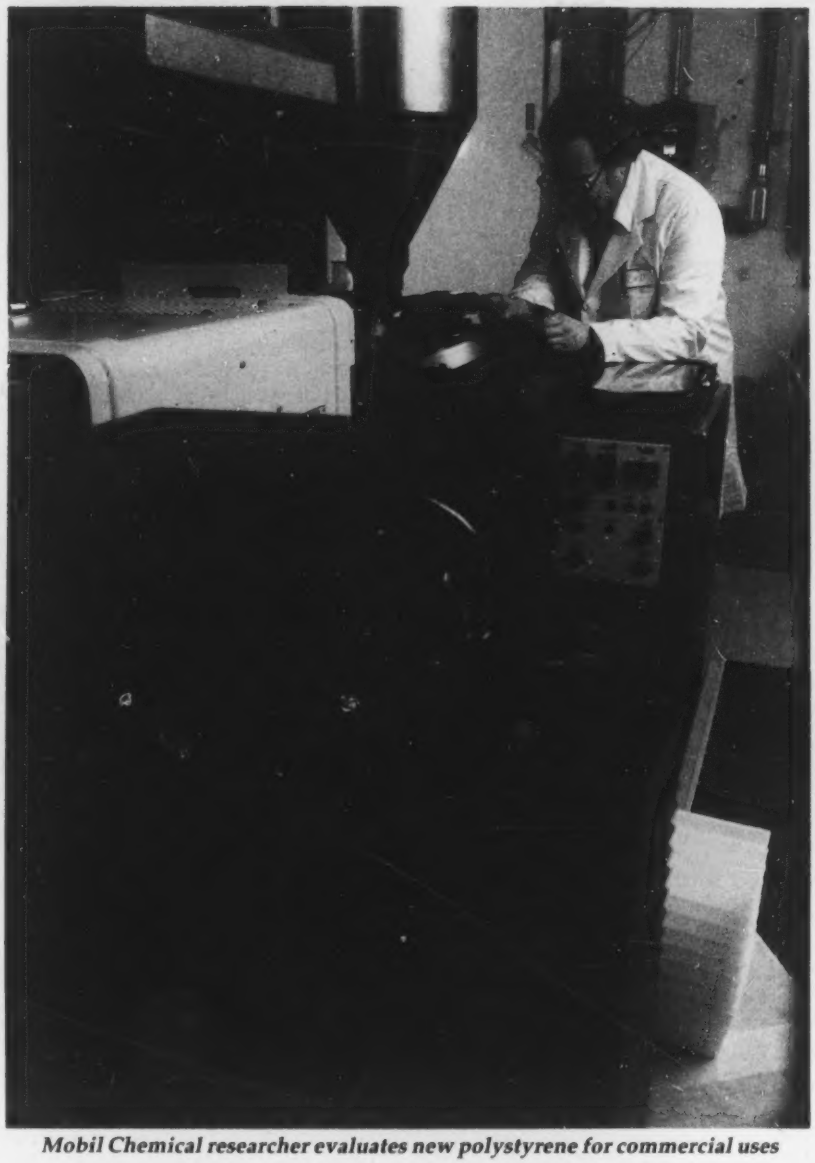
The company also has begun construction on a plant for ABS capacity of 40,000 metric tons at Terneuzen, the Netherlands, scheduled to begin operating in 1990. Current demand for ABS resins in Europe is about 425,000 metric tons, with demand expected to reach 475,000 metric tons by 1990. Nameplate capacity for ABS in Western Europe has been nearly flat since 1980, Dow says, and producers are currently running at 88 to 92% capacity utilization.

For polycarbonates, a new plant, to be located "somewhere in Northern Europe," will feature Dow's own technology already being used in Freeport, Tex. Start-up is planned for 1990. The attendant polycarbonate compounding plant will be located either at Terneuzen or at Stade and will start up next year.

The manufacturing, or compounding, plant is scheduled to have capacity of 35,000 metric tons per year, but even given recent announcements of polycarbonate expansions by Bayer and General Electric, Dow officials don't see a danger of overcapacity. They are predicting a growth in Europe for polycarbonate of about 8% per year, "a conservative estimate," that probably actually will be nearer 10% per year.

Patricia Layman, London

Plastics In Midst of Banner Year



Mobil Chemical researcher evaluates new polystyrene for commercial uses

Bruce F. Greek, C&EN Houston

Profitability in the plastics industry this year will be the best of this decade. Production and demand will increase substantially above 1986. Prices for most plastics will be well over last year's. And most of the individual polymers again will set production records. By all accounts, plastics are in the midst of a banner year.

What's more, a large number of new polymers and variations on existing polymers are coming out of research and development laboratories, which bodes well for potential new growth for the industry.

Among the largest volume plastics, thermoplastics (polyolefins in particular) are in high demand this year. Polyethylene and polypropylene will account for just under half of 1987 production of 39 billion lb of thermoplastics. Counting polyvinyl chloride production, these polymers will make up almost two thirds of thermoplastics output. As a group, production of all of the thermoplastics will increase about 7% this year. An increase also is expected in thermoplastics production next year, but it probably will not be so large as in 1987, because certain thermoplastics have capacity limitations.

The smaller sister group of plastics, thermosets, are more mature and their output will grow more slowly. However, it seems certain that production will top 6 billion lb this year, up almost 3.5% from 1986, excluding polyurethanes. Future growth of thermosets will be lower than that of thermoplastics, probably falling to less than 3% annually next year, and less later on.

By and large, there seem to be few problems in the plastics industry at this time. However, there is some concern that inventories of some of the major-volume plastics might be building. Rising imports of plastics products and of some resins will reduce what might otherwise have been even larger U.S. production. Collection, disposal, and possible recycling of unwanted plastic products have gained much attention both inside and outside the industry. Limitations on plant capacity to make monomers and polymers are curtailing some of the current optimism for next year and beyond. And capital expenditures needed for new polymerization and fabrication units are large, and it's not certain which companies, if any, are going to shell out those funds for new plants.

Based on estimates through May of this year, 1987 production of plas-

Low-density polyethylene production nears 10 billion lb

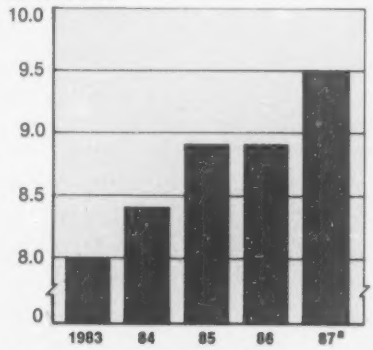
This year, U.S. production of all forms of low-density polyethylene (0.94 g per cc or less) will reach 9.5 billion lb, up about 7% from 1986 output of more than 8.9 billion lb. Between 7.0 billion and 7.5 billion lb will be conventional low-density polyethylene (LDPE) and the remaining 2.0 billion to 2.5 billion lb will be the newer linear low-density polyethylene (LLDPE).

Next year, a milestone will be reached for LDPE. U.S. production likely will top 10 billion lb. It will be one fourth of forecast global output of 40 billion lb in 1988. Because of expected slower economic growth and increased saturation of some of the major polyethylene markets, production is forecast to grow less next year than this year.

Capacity to make LDPE resins currently is adequate. Counting some recent debottlenecking, the U.S. capacity totals close to 11.25 billion lb. About 750 million lb is swing capacity that could be used to make high-density material. An additional 3 billion lb of the remaining 10.5 billion lb of capacity can be used to make either LLDPE or high-density polyethylene.

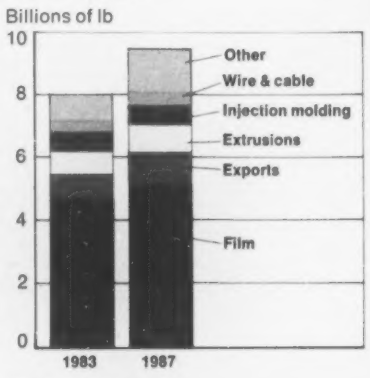
Sales and captive use of U.S.-produced LDPE and LLDPE are dominated by film manufacture, which will take more than half of the total, or some 5.2 billion lb this year. More than half of the film total goes to various kinds of packaging. The packaging area is split evenly—half for commercial and industrial packaging and half for food packaging and retail bags. Some of the retail bags eventually become competitors for trash bags. Trash bags are considered to be a nonpackaging use of film and (by a slight margin) the largest use of film.

Production



[a] C&EN estimate. **Source:** Committee on Resin Statistics, Society of the Plastics Industry

Consumption



Source: C&EN estimates

Other significant uses of LDPE and LLDPE are in a host of injection-molded items, in extrusion coatings on paperboard or in paper and foil composites, and in wire and cable coatings. (LDPE's original use in World War II was coating for wire used in early radar.)

Exports of these polyethylenes continue to be high. But imports, especially from Canada, have been growing and are near the level of exports. Future changes in exports and imports likely will be determined by costs of ethylene at producing locations.

tics of all types likely will reach 54.5 billion lb, up more than 3.7 billion lb from 1986, or about 7.3%. This growth rate is well above the average rate for this decade, because production declined 8.3% in 1982 during the last major recession. The current surge in plastics demand began during the second half of 1986 and helped lift output last year 6% overall. Production growth next year likely will slow, because of a need to reduce inventories and the lack of spare capacity to make the large-volume thermoplastics.

Growth may slow even further beyond next year. Chem Systems, a consulting firm headquartered in Tarrytown, N.Y., forecasts in a study for the Society of the Plastics Industry that production in the year 2000 will total 75.5 billion lb. To achieve an increase of 21 billion lb in 13 years, production must grow on average slightly more than 3% annually. The study—"Plastics: A.D. 2000," by Chem Systems—was prepared as part of the 50th anniversary observation of SPI. It expects two recessions to occur before 2000. One recession, considered to be the milder of the two, is forecast to begin in 1989 and end in 1990. The other, arbitrarily set for 1996 to 1998, is expected to be more severe. The two recessions could reduce plastics production as much as did the recession of the early 1980s.

Concerns about recession and the impact of reduced production, sales, and returns are as big in the plastics industry as elsewhere. Wrinkles in the general economy are widely felt because of the sheer size and complexity of the industry. For example, this year sales of unprocessed polymers produced by the industry will exceed $20 billion. According to a survey made by the SPI in 1985, including subsequent processing, fabrication, and other work by which value is added to the basic polymers, the total value of sales that year was almost $140 billion. Capital investments in 1985 were about $6 billion. The share of the investment in basic polymer-producing facilities was not large that year because of sizable surplus capacity.

Although both production of basic polymers and the volume fabricated into end products are rising, many changes are due in the plastics industry. Consumption patterns change continually. The "Plastics: A.D. 2000" study indicates that packaging will continue to grow in share of consumption of all plastics, reaching 30% of the total by the end of the century, up from 28% in 1985. Consumption of all plastics in electrical and electronic components and by transportation equipment represents smaller uses that are still growing.

All three major markets are expected to increase their share of to-

tal plastics consumption because of demographics. An aging population living in smaller family units will require more convenience and comfort. Packaging, therefore, will shift toward more single-service containers, aesthetically appealing disposables, and aseptic packages. Comfort demands will increase plastics consumed in home entertainment equipment, other appliances, and transportation equipment.

Construction's share of plastics consumption will decline, however, according to the Chem Systems study, largely because the use is growing more slowly than are several others. Nevertheless, construction will take 20% of all plastics consumption in 2000, down from an estimated 22% in 1987. Consumer products' share of total consumption is expected to decline, as is exports' share.

Several end uses of plastics that are holding their share of the total market are classified by SPI as adhesives, inks, and coatings; consumer and institutional products; electrical and electronic; furniture and furnishings; industrial; transportation; and other. Each of those categories, although holding its share of the total market, comprises segments that will grow or decline. Future life styles and the type of services demanded will determine that growth or lack of it.

The category of adhesives, inks, and coatings does not include adhesives used to bind plywood and particle-board wood fibers; those polymers are included in the construction-use category. Many of the materials included in the adhesives, inks, and coatings category grew in use because they captured markets from other materials. They now dominate certain markets; for instance, polyvinyl acetate has a large share of latex paints, and thus its use will grow little. Other plastics, such as the epoxy resins, are relatively expensive, and that limits growth. New adhesive uses—for example, the replacement of mechanical fasteners—are likely to be the area of largest growth.

Consumer and institutional products include uses of plastics in such areas as toys, housewares, recreational equipment, medical equipment and disposables, and business equipment. Plastics have considerable potential to capture markets in this category from metals, glass, nat-

High-density polyethylene continues to record strong growth

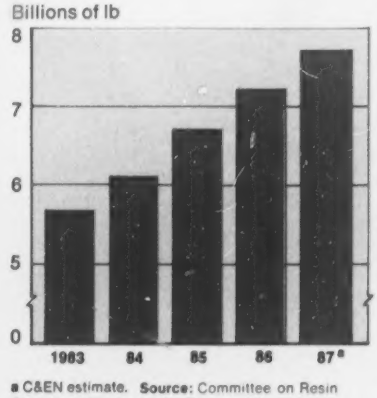
Production of high-density polyethylene (HDPE), whose density is above 0.94 g per cc, is still growing unabated. Output this year may reach 7.7 billion lb, a rise of 7% that will approximate last year's increase. Continuing development of new markets for HDPE is behind this growth.

The capability of some producers to shift use of some of their capacity between production of HDPE and linear low-density polyethylene (LLDPE) solves the problem of current limits on conventional HDPE capacity. The newer units designed as dual capacity, for making either kind of polyethylene, total about 3 billion lb. Another 0.75 billion lb of capacity is designated as swing capacity for either HDPE or LLDPE, for it can be quickly shifted between the two products. The dual capacities are generally newer than some 6.5 billion to 7.0 billion lb of capacity initially built to make HDPE and subsequentiy debottlenecked to the higher estimate, or to possibly more.

Demand for LLDPE also continues to be strong in such end uses as film for a variety of bag applications; as a result, not much of the LLDPE capacity may be available to make HDPE. It is apparent, therefore, that to make the 7.7 billion lb of HDPE forecast for this year, all of the basic capacity, most of the swing capacity, and a small part of the LLDPE capacity must be utilized.

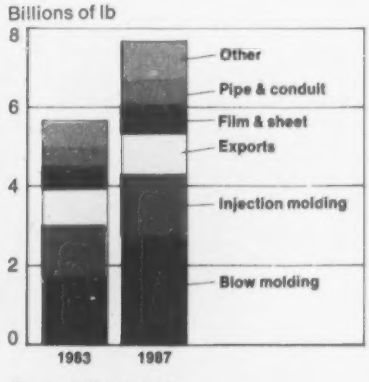
Pressure is put on HDPE capacity predominantly by the container market. A decade ago, the swing began toward blow-molded milk, juice, and noncarbonated drink containers in the 1-gal and 0.5-gal sizes, as well as toward bottles for household bleach, antifreeze, and many other consumer products. More recently, a surge toward motor oil bottles has kept HDPE demand growing, even as growth in other uses has settled down to nearly population growth. Other current, fast-growing uses are in shipping drums and automotive vehicle fuel tanks.

Production



a C&EN estimate. **Source:** Committee on Resin Statistics, Society of the Plastics Industry

Consumption



Source: C&EN estimates

In the area of injection-molded HDPE, a host of new industrial items are being developed. Moreover, additional growth is forecast in demand for HDPE open-headed containers, primarily in the 5-gal size. Demand for materials-handling items such as pallets, crates, and trays also is increasing rapidly.

Extrusions of HDPE, mainly film (often blended with LLDPE), go into merchandise bags and many other forms of packaging as well. Film has been successfully challenged by pipe and conduit as the largest extrusion use. Both of these use areas will grow about as fast as will other uses of HDPE.

Capacity limits polypropylene demand growth

Limited capacity to make polypropylene will hold down production growth this year. Polypropylene production will rise to 6.3 billion lb, up more than 8% from 1986, but demand would push production even more if more capacity were available.

This year began with U.S. polypropylene capacity at about 6.3 billion lb. During the year, several producers have made major additions and debottlenecked operations to add 300 million lb to annual capacity. Total capacity will be about 6.6 billion lb at the end of 1987. Because the additions will be producing for just part of this year, however, capacity will be strained to meet demand. And since demand growth continues to keep pace with capacity growth, the tight supply-demand situation will continue next year even as other major capacity expansions start up.

Additional polypropylene for U.S. markets could be diverted from the substantial exports of the plastic; consumers would merely have to pay a price higher than the export price. Exports in 1987 could reach 1.25 billion lb, possibly 1.5 billion.

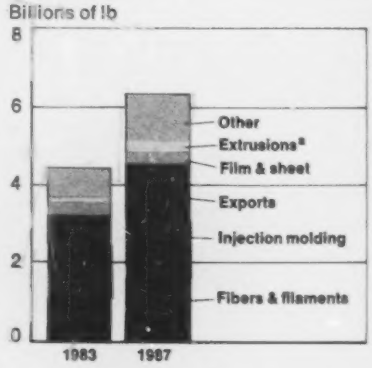
The relatively large exports are the result of limited availability of polymer-grade propylene in some Asiatic and Latin American countries. Although no major changes in export demand for polypropylene are expected for the near-term, additions of steam crackers in the Far East eventually could reduce polypropylene exports from the U.S.

Among major uses of polypropylene, a wide variety of injection-molded items take nearly a third of consumption. One major end use of those items is in transportation, such as in auto components and battery cases. Another is packaging, including many kinds of containers and the caps and lids for various containers made of other plastics. Many other consumer, medical, and appliance items use this plastic. Expected growth rates for polypropylene in these varied uses range from about zero to very high rates for some automotive components.

As a use for polypropylene, fibers and filaments run a close second to injection-molded items. This use as a group is growing more slowly. The most rapidly growing segment of the market is the nonwovens.

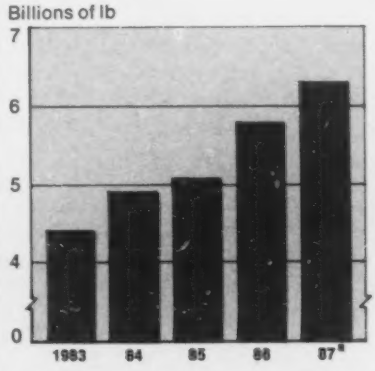
Other applications include film, sheet, blow-molded items (largely bottles), and many small-volume products. They will grow about 5% annually.

Consumption



[a] Other than film. **Source:** C&EN estimates

Production



[a] C&EN estimate. **Source:** Committee on Resin Statistics, Society of the Plastics Industry

ural and synthetic fibers, and ceramics. Growing interpolymer competition partly handicaps those markets. Changing interests and fads intermittently affect use in toys, housewares, and recreational equipment. In medical markets, high growth of plastics will continue, as plastics replace glass and metal in both disposable and sterilized items. Disposable plastic-film-based gowns and various other kinds of coverings are replacing fabric items that have to be laundered. These dispos-

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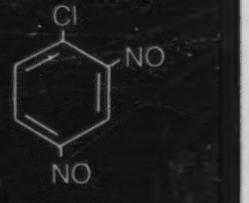
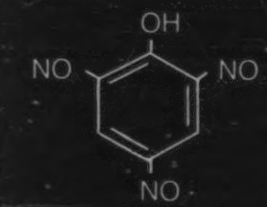


DNCB CAS 97-00-7

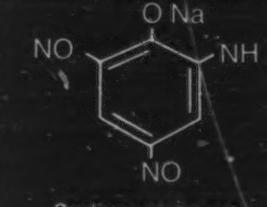
2,4,6, Trinitrophenol



Picric acid

Send spec sheet CAS 88-89-1

Sodium 2-amino-4,6-dinitrophenolate



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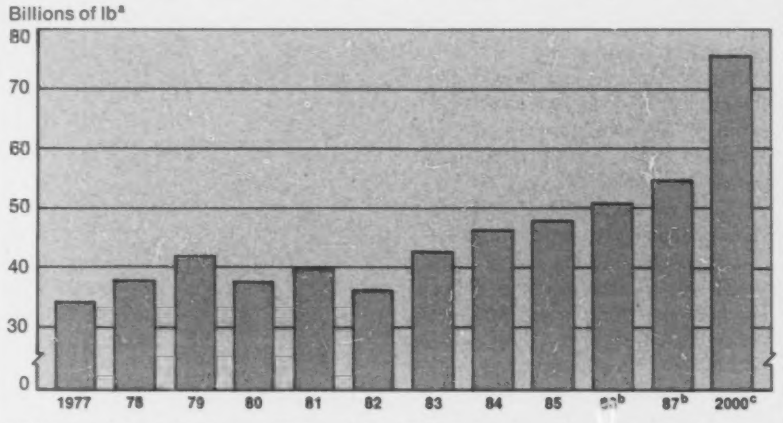
ables could become the fastest growing items in the medical market. Cookware for microwave ovens (both disposable and reusable) could be the second fastest growing area. But that growth will be offset by lower use of plastics in toys and recreational equipment, as the population ages and demand for those items falls.

The electrical and electronic devices market is one of the smaller end-use areas of plastics that will have an increase in share of consumption, according to Chem Systems. SPI includes in this group all kinds of appliances, computers, industrial equipment, auxiliary parts, and many other items. Capture of markets by plastics in that category varies widely. From the beginning, cases for some products (computers, for example) were made of plastic. In small household appliances, such as mixers, plastics have become the dominant material, replacing metal in the casings.

Plastics output forecast to grow nearly 40% by year 2000



a All types, including polyurethanes. b C&EN estimate. c Chem Systems Inc. estimate for Society of the Plastics Industry. **Source:** Committee on Resin Statistics, Society of the Plastics Industry

Extensive replacement of metal by plastics in large appliances has yet to occur in the electrical and electronics market. Potential for growth in this market lies in housings made of plastics, whereby assembly could be simplified and much painting eliminated, lowering the final cost of an appliance. Further development and modification of polymers and of fabrication techniques will be necessary if plastics use is to increase rapidly and rise above the 5% of materials now used in appliances.

Furniture and furnishing uses of plastics are dominated by two kinds of polymers—polypropylene and polyurethane. No growth in market share by 2000 is forecast for those uses, partly because of the decline in PVC use in flooring and furniture. In a kind of interpolymer competition, polypropylene fibers in carpet and fabrics have made large inroads into use of PVC. Though much of the shift toward polypropylene has been completed, overall use of plastics in furniture and furnishings is expected to grow, as the number of households increases and as they require more items, and as the population ages and demands easier maintenance of household equipment.

Furniture and furnishings account for more than a third of consumption of polyurethane foams, almost entirely flexible foams. Another sizable share of polyurethanes goes into similar products, such as seating in automobiles and trucks, which is categorized as transportation equipment. The other major use of polyurethanes, in building and construction, is mostly as insulation in roofing and sheathing.

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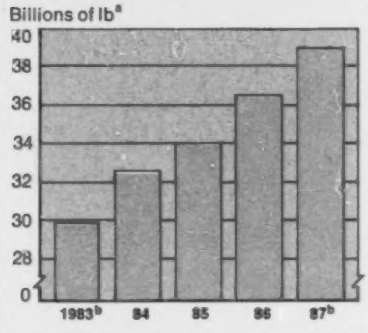
CIRCLE 39 ON READER SERVICE CARD

Thermoplastics production keeps growing unabated

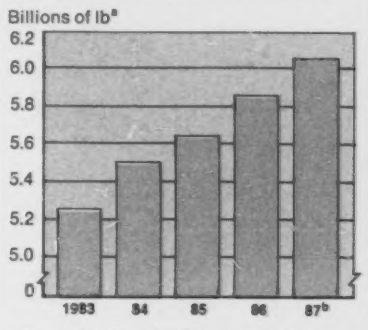


a Acrylonitrile-butadiene-styrene, nylon, polyethylene, polypropylene, polystyrene, polyvinyl chloride, styrene-acrylonitrile, and thermoplastic polyester. b C&EN estimate. **Source:** Committee on Resin Statistics, Society of the Plastics Industry

The industrial market share of plastics is small and is expected to remain so. Capture of markets from metals has been slow and spotty. Because of the higher performance required, the more expensive engineering resins—phenolics and other thermosets, as well as specialty resins, including the newer blends and alloys—account for much of the consumption in this market.

Use of plastics in transportation occurs mostly in the passenger car and light truck area, which will show slow market share growth despite the potential to capture market from metal. That is because car production will grow slowly in the future, even though Japanese manufacturers are adding to their U.S. operations. Much of the future growth in those areas will occur in exterior body components, because auto makers have gone about as far as they can in using plastics for interior and under-hood parts. Further developmental work, however, is needed before problems in paint technology and in differences in thermal expansion between plastics and metals are overcome. Other transportation equipment uses are in mass-transit vehicles and aerospace, both of which are growing in usage of plastics but from small bases.

Thermosets output is growing slowly but steadily



a Epoxy, melamine, phenolics, unsaturated polyester, and urea. b C&EN estimate. **Source:** Committee on Resin Statistics, Society of the Plastics Industry

Another use category includes the large quantities of plastics sold by producers to resellers and compounders. Most of the volume even-

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CIRCLE 63 ON READER SERVICE CARD →

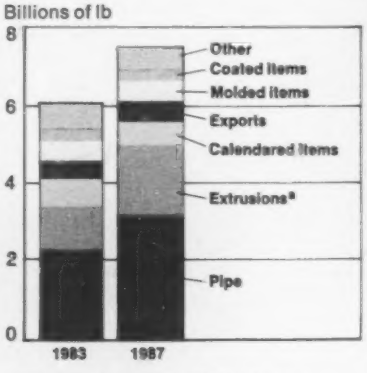
Polyvinyl chloride growth resumes at slow pace

Somewhat slower growth is forecast for polyvinyl chloride production than for other major-volume thermoplastics this year. PVC output will exceed 7.6 billion lb in 1987, up about 5% from last year. Next year's growth rate likely will be about the same.

Current midyear capacity to make PVC by the various polymerization technologies—bulk, emulsion, solution, and suspension—including copolymerization capacity, totaled about 8.8 billion lb. That estimate excludes some units that have been shut down for some time; these units account for less than 500 million lb and aren't likely to be restarted. Because production time is lost when grades are changed and because of technical restrictions posed by stringent emission controls, an annual output of more than 8 billion lb would require plants to be run full out. Nevertheless, debottlenecking of capacity continues as technology improves in catalysts, emission control, and polymerization.

Late last year and early this year, sales and use of PVC rose more rapidly than output of PVC, drawing down inventories. Since then, output has moved closer to sales and use. Consumption may slow this summer as a result of a slowdown in new housing construction.

Consumption



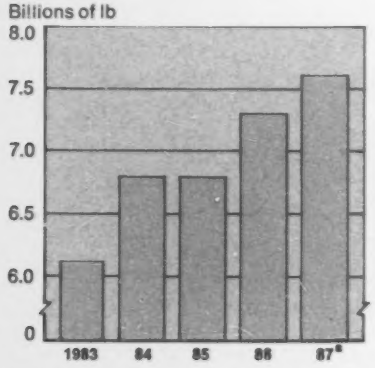
a Other than pipe. **Source:** C&EN estimates

Construction dominates use of PVC, with extruded pipe and conduit taking nearly half of U.S. consumption. Besides pipe, other construction uses are in such extrusions as siding and guttering. They also include molded items such as pipe fittings, calendared items such as flooring, and coated items such as wall coverings. Wire and cable coverings and fittings take another sizable quantity of PVC into the construction market. Future growth for PVC, in effect, will depend on construction and, to some extent, remodeling.

Other end uses include a host of consumer products ranging from phonograph recordings to toys and garden hose. PVC film and sheet have a continued market in packaging and in transportation equipment. As a group, the nonconstruction uses of PVC are growing at a little above population growth.

PVC demand could increase significantly if imports of fabricated PVC products, mostly consumer goods, are restricted by government regulations. Estimates of the quantity of PVC used in imported items cluster around 1 billion lb annually. These imports are rising faster than domestic demand for PVC.

Production



a C&EN estimate. **Source:** Committee on Resin Statistics, Society of the Plastics Industry

tually may be included in one or more of the other categories, with some of it as off-specification material sold on the basis of its price and not on its potential performance. SPI's Committee on Resin Statistics is attempting to reduce this category to reflect more clearly the consumption patterns for plastics.

The big jump in exports of plastics clearly is over. Although exports may rise for certain polymers—polypropylene and some engineering plastics now entering the commod-

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Polystyrene demand eases and production closes the gap

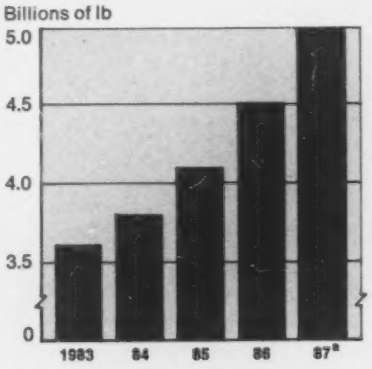
Sales and captive use of polystyrene outstripped production well into the second quarter of this year, and inventories fell. That demand pressure, along with a brief increase and then decrease in benzene prices, advanced polystyrene prices to well above 50 cents per lb before a summer softening began.

With demand pressure now eased, production is forecast to be about 5 billion lb this year, up 11% from 1986. To reach that level, plant operations will have to be pushed to about 90% of nameplate capacity of 5.6 billion lb. Output and capacity of crystal, impact, and expandable bead forms of polystyrene are included in the estimate.

Output growth has been possible because of a recent round of minor capacity expansions—the first in some time other than debottlenecking. Other expansions expected by 1989 will total less than 10% of current capacity, which is about the same amount that demand is expected to grow during that time.

Polystyrene uses are similar to those of polyethylenes, in that more than half of consumption goes into disposable items, particularly into many kinds of packaging. Other disposables include food serviceware and medical devices.

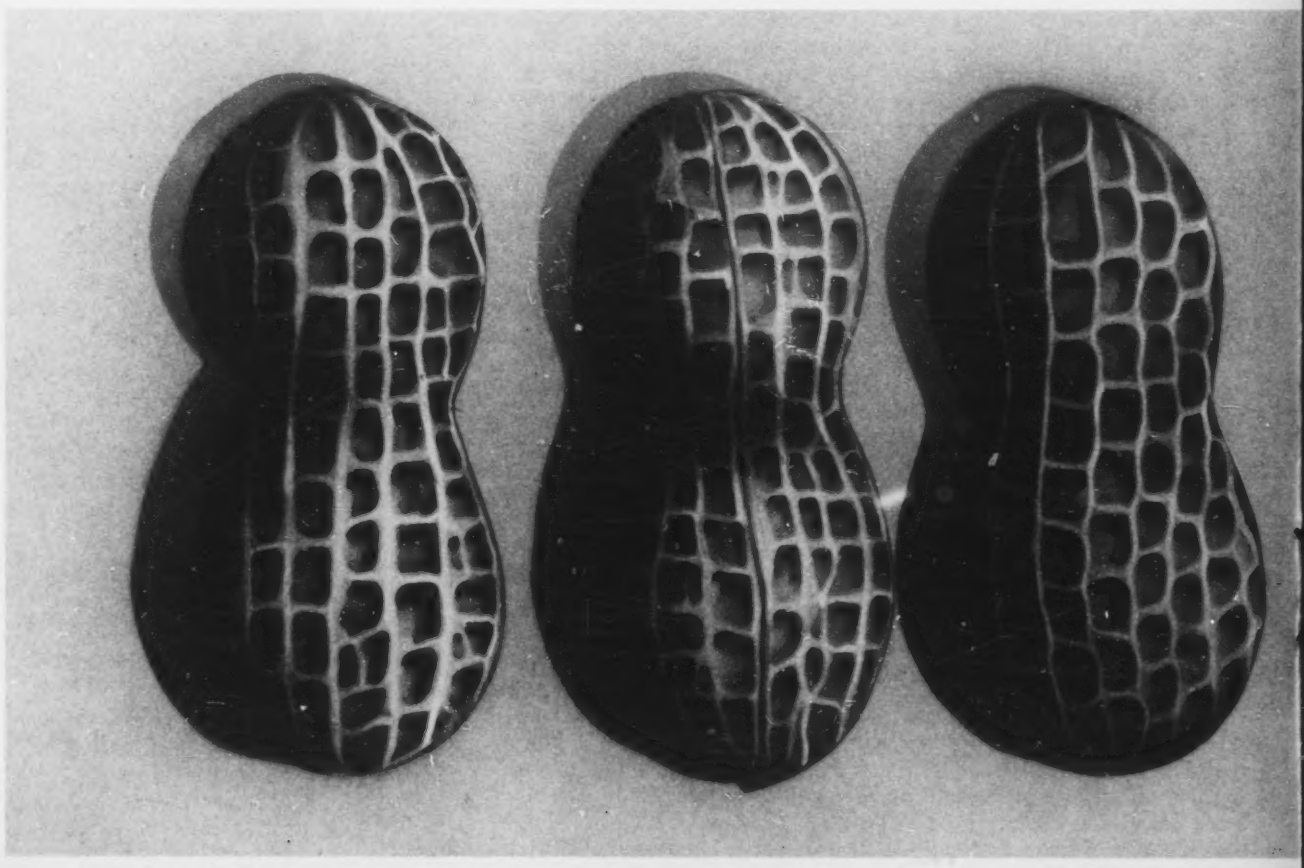
Production



[a] C&EN estimate. **Source:** Committee on Resin Statistics, Society of the Plastics Industry

Demand growth for polystyrenes used in disposables barely exceeds population growth. Polystyrene has few markets left in the disposables area that can be captured from nonplastic materials. Part of the disposables market of polystyrene has, in fact, been lost to other plastics that cost less or are easier to fabricate. Thus, although polystyrene demand will surge this year, the growth rate will decrease. However, demand for disposables does not decline much during times of economic recession, and that could help future polystyrene demand, assuming a recession occurs.

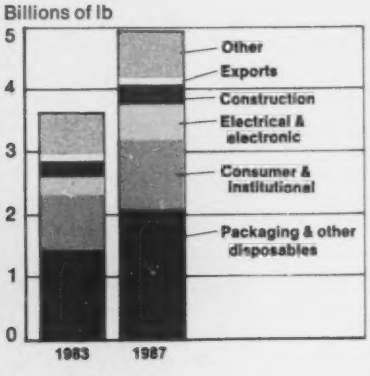
Polystyrene resins also go into a



host of longer lasting consumer and industrial products, including many kinds of housewares, toys, appliances, home and office furniture and furnishings, recreational items, and electrical and electronic parts. Some of those applications will have low growth, especially those facing competition from other plastics. Use in appliances and furniture and furnishings will grow 4 to 5% as polystyrenes are developed to compete with the more costly plastics. Construction use—foamed sheet or board, in particular—will depend mostly on industrial and commercial construction and will grow at rates above that of total construction, as energy conservation efforts continue.

Foamed polystyrene is one of the growth areas of packaging. It is used increasingly in the "clam shell" containers for fast foods, in egg cartons, and in loose-fill and molded packaging. High-impact polystyrene is finding growing use in appliance cabinets, computer parts, and furniture. These applications will help push polystyrene demand growth to about 5% annually.

Consumption



Source: C&EN estimates

ity-size classification—the growth in exports will be up much less than will total growth in production. Chem Systems projects exports in 2000 at 5.16 billion lb, up a little more than 1.2 billion lb from 1985 exports. Low growth in exports will result largely from competition in Latin America and Southeast Asia, beginning by 1990.

Imports of both intermediate and finished plastics products, as well as products containing plastic components, have considerable impact on U.S. plastics production. Imports of molded items such as toys, household items, components for appliances and other mechanical goods, and apparel have been growing fast. Film and plastic bags have recently become sizable imports. Imports of cars and electronic equipment bring in large quantities of plastic components. Changes to be made in these imports are difficult to forecast before a trade bill is passed. Even if passed, a trade bill probably

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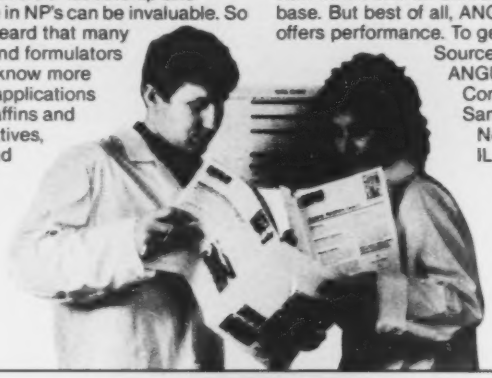

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would merely slow the growth rate of imported fabricated plastic products. Consequently, loss of potential polymer production and subsequent fabrication in the U.S. will continue, diminishing the volume of plastic products that might otherwise be made in the U.S.

Each of the major raw materials used in plastics—ethylene, propylene, and benzene—was given closer attention during the first half of this year, because of the questions about current and future availability. For example, present operating ethylene capacity is being run at about optimum levels. A considerable amount of additional ethylene capacity, shut down because of the recession in the early 1980s and not yet operating again, could be restarted if producers find that the costs of doing so would be covered by returns from the operation of this capacity. Additional ethylene production will result from various debottlenecking programs for currently operating units.

Industry views on when more capacity will be needed vary, depending on the forecasts for growth in plastics demand (and in turn ethylene demand). One scenario suggests that, with about a 6% growth in demand in 1988, currently operating ethylene capacity will supply

Packaging will remain largest use of plastics

	Share of plastics market		
	1970	1985	2000
Packaging	24%	28%	30%
Building & construction	21	22	20
Consumer products	11	8	7
Electrical & electronic	10	6	7
Adhesives, inks, coatings	8	5	5
Furniture & furnishings	7	5	5
Transportation equipment	5	5	6
Industrial	1	1	1
Other	7	12	12
Exports	6	8	7
Production (billions of lb)	19.2	47.8	75.6

Source: Chem Systems Inc. for Society of the Plastics Industry

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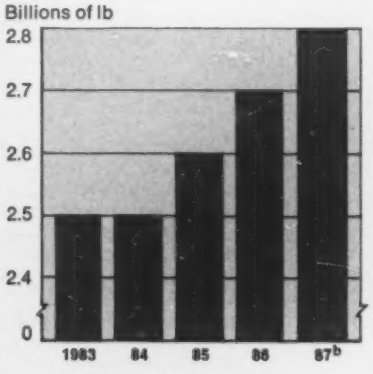
Growth in phenolic resins will remain slow but steady

Historical performance of slow and steady growth again will characterize the various phenolic resins this year. Production growth will remain small because the long-established phenolics are going into few new markets and because existing uses are mature. Nothing short of a major economic downturn could alter that pattern either this year or next. Output of phenolic and other tar acid resins this year will rise about 3% to 2.8 billion lb, on a gross weight basis.

Most phenolic resins are products resulting from reactions of phenol with formaldehyde. Many variations in the final products are offered commercially or used captively to make specialized end products.

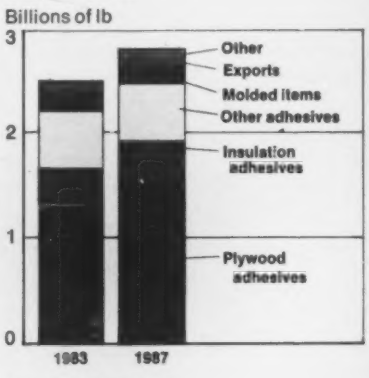
Most of these resins are made in batch operations in large vessels with little auxiliary equipment. Consequently, investment costs are low and the product cost depends heavily on the raw materials costs. The increase in benzene prices during the second quarter, because it affected phenol costs and availability, temporarily upset phenolic resin prices. However, prices now have settled back into the usual highly competitive conditions.

Production[a]



a Gross weight basis. b C&EN estimate.
Source: Committee on Resin Statistics, Society of the Plastics Industry

Consumption



Source: C&EN estimates

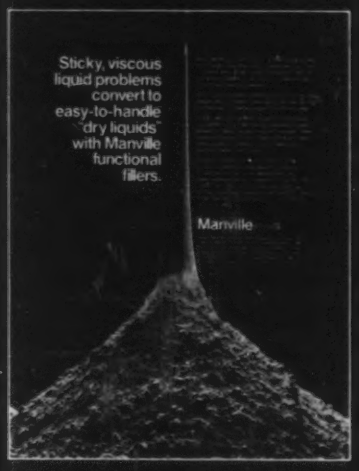
Reliable estimates of capacity to make phenolic resins are not available for several reasons. During downtimes (for shifting to manufacture of different resins), capacity is lost. As requirements for use change, operating of plant units may be intermittent. And some equipment is used to make resins other than phenolics.

Accurate production estimates also are unavailable. Because of uncertainties in reports of resin production, the Committee on Resin Statistics of the Society of the Plastics Industry shifted its reports to a gross-weight basis in 1981, thereby including the weight of fillers and carriers. Depending on the end use, the actual resin content of the product shipped or used varies from less than 50% to more than 80%.

Most phenolic resins are used as adhesives. Plywood adhesives alone consumed more than half of production. Adhesives for wood fiberboard rank third in consumption after insulation materials such as glass fiber adhesives. Thus, the outlook for these resins depends on construction, which has grown only slowly for some time. Nonadhesive uses are largely in molding compounds for making many different consumer and industrial products. Growth in these uses also has slowed.

all needs next year. Because of additional debottlenecking, restarting part of the shut-down capacity each year, shifting the average feedstock composition, and a slowing of demand during a mild recession in 1989, no additional new capacity may be needed until 1991, or possibly 1992.

Supply of propylene is partially related to ethylene production as one of the coproducts of steam cracking of hydrocarbons. Because of the demand surge for polypropylene,



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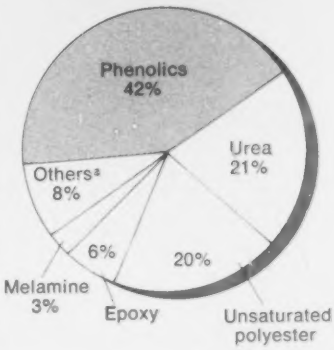
supplies of polymer-grade propylene have become tight, and prices for both it and chemical-grade propylene have increased to levels well above the price for ethylene. That is a reversal of the historical situation in which propylene prices were typically 75% of ethylene prices. The rise in prices for propylene has led to the expected result of drawing sufficient propylene from other sources (such as refineries, where it is made in catalytic cracking units) to meet chemical and polymer demands. Longer term, propylene supplies will be large enough to meet nonrefinery demands, as long as consumers pay a price competitive with the alternative value to refiners.

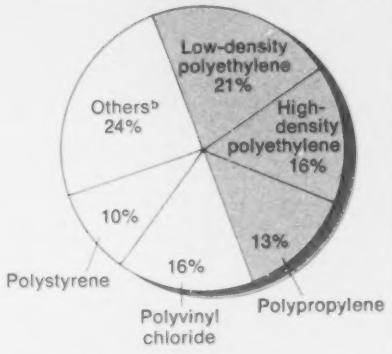
For the other major raw material for polymers, benzene, more than three quarters of its consumption in chemicals goes to styrene, most of which is polymerized to polystyrene. The increase in benzene prices during the second quarter was largely a result of marketing events and not the result of large demand growth. As is the case for propylene, plenty of benzene is available in refineries (besides that coproduced in steam cracking). So, if consumers pay a price competitive with alternative use in gasoline, supply of benzene will meet all demands for use as a raw material in making

Phenolics dominate thermosets production...



1987 production = 6.05 billion lb

...and polyolefins lead thermoplastics production



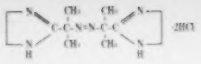
1987 production = 39.0 billion lb

a Includes alkyds and silicones. b Includes acrylonitrile-butadiene-styrene, styrene-acrylonitrile, polyvinyl acetate, and thermoplastic polyester. **Source:** C&EN estimates

PRODUCT PROSPECTUS

For High-Performance Polymers

VA-044



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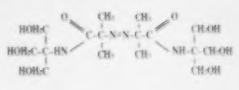

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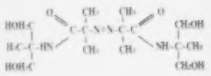

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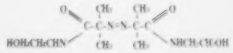

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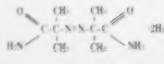

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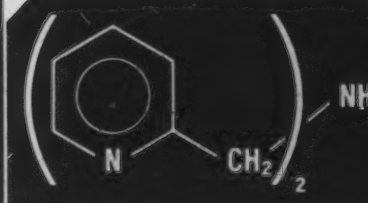

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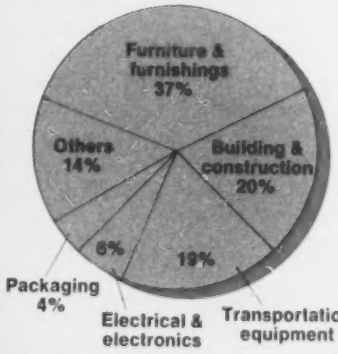
polystyrene, nylon, polyurethanes, and other smaller volume plastics.

Capacity to make intermediates used in some of the smaller volume plastics also has been growing tighter. Capacity to make those intermediates is expanded with much less notice than is given to major ethylene projects. Supplies of intermediates for the specialty plastics are now forecast to adequately meet near-term demands for those plastics.

The many smaller volume (noncommodity) plastics are hard to categorize. One group is called engineering resins. Another may be called performance plastics. Definitions overlap. For example, some resins may be commodities in some uses and engineering resins in others. Nylons, for uses other than in fibers, have long been called engineering resins, but SPI's Committee on Resin Statistics reports production and sales and captive use in a list of thermoplastic resins that includes the major-volume polyolefins. Nevertheless, nylon production exceeds, by several-fold, production of some of the other resins that are reported in the thermoplastics category.

Numerous thermoplastic engineering resins are included in the committee's list: acetals, fluoropolymers, modified polyphenylene oxide, polycarbonate, polyamide-imide, polyimide, polyphenylene sulfide, polysulfone, and thermo-

Three markets dominate polyurethane foam use



1985 production = 2.13 billion lb[a]

[a] Latest data available; both flexible and rigid foam.
Source: Committee on Resin Statistics, Society of the Plastics Industry

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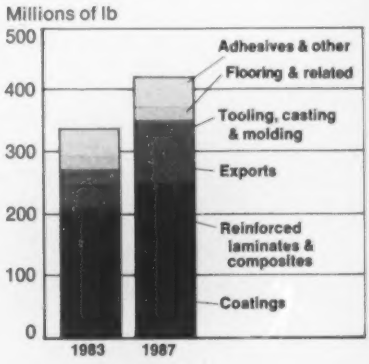
New production record forecast for epoxy resins

Renewed growth in some important uses of epoxy resins will increase production this year to a record of about 420 million lb, up more than 5% from 1986 production. The previous output high was set in 1984 at 406 million lb. In recent years, epoxy resins have become noted for relatively wide swings in production and in certain areas of consumption.

Despite a sizable upturn in production this year, capacity to make epoxy resins will not be strained as is capacity for polyolefins. Current capacity to make the basic epoxy liquid resins is about 500 million lb, or perhaps a little less because of losses in output during shutdowns to change kinds of epoxy products. There is additional capacity to make modified and solid resins from the basic liquids, but that capacity is considered to be downstream processing, not primary capacity.

Because the epoxide group on compounds is so reactive, many different kinds of epoxy resins are offered commercially and more continue to be developed. The kind of curing (cross-linking) epoxy resins undergo offers an even larger variation in final products. Curing agents cover most classes of organic compounds. The number of chemically different epoxy resins that are of some commercial significance exceeds 100.

Consumption

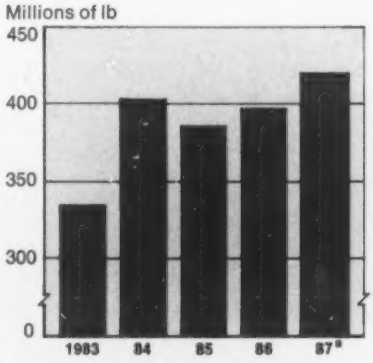


Source: C&EN estimates

Among domestic uses, various types of coatings continue to grow and account for about 40% of total use. A large number of companies make the components of epoxy resins coatings by buying epoxy resins from basic manufacturers. Containers, especially beer and soda pop cans, are the largest market. Automotive primer coatings rank second, a use that varies with the levels of auto production. Other uses of epoxy resins in coatings range from appliances to marine components to some architectural products. Coating uses of epoxy resins are forecast to grow at about the overall rate for all epoxy resins, or 3 to 5% annually.

Laminates and composites use about half the volume of epoxy resins as does the coatings area, with printed circuit boards dominating. Consumption of casting and molding resins that go mostly into electrical and electronic components has slowed. Adhesives and bonding agents generally are made by formulators who sell to consumer and industrial markets. A large number of other small uses make up the remaining consumption.

Production



[a] C&EN estimate. **Source:** Committee on Resin Statistics, Society of the Plastics Industry

plastic polyester. Many others are included in other lists, such as polyarylate, polyethersulfone, polyetherimide, and liquid crystal polymers.

Some of these polymers are produced in small quantities, whereas others now have outputs near 100 million lb. Total production of thermoplastic engineering resins in 1987 could total about 1 billion lb, excluding nylon and thermoplastic polyester.

As with nylon, thermoplastic

polyester has become so large in volume (1987 production is forecast at more than 1.3 billion lb) that it is reported separately. The rapid rise in production results from its almost total acceptance for 2-L soft-drink bottles. The plastic also is used extensively for making myriad other packaging items, such as bottles for many kinds of noncarbonated beverages, cosmetics, medical products, and food products; as film; and as trays capable of being used either in microwave or conventional ovens.

Many of the engineering and performance resins cost more than the commodity resins. The high cost has limited their ability to capture markets from other materials, particularly from metals, because the cost-performance characteristics were below those of metals. But that situation may be changing, as development work advances the properties of the resins through techniques of alloying and blending polymers, as well as through use of additives, through compounding, and by other methods of fitting plastics to specific needs.

Alloys and blends are not entirely new. One blend, high-impact polystyrenes, was first produced in significant volume many years ago. Plastics that are alloys or blends have definite differences. Polymer alloys are similar to metal alloys in that molecular forces—the dipole moments, hydrogen bonding, and van der Waals forces—are stronger than in blends. They do not, however, have covalent bonds as do copolymers. Because of those intermolecular forces, alloys can resist the effects of heat, light, oxygen, and chemicals better than can blends or single polymers. An example of a commercially available alloy of plastics is polyethylene terephthalate (PET) with polybutyl terephthalate (PBT).

Besides development work in alloys and blends, other work is being done in the area of composites. The combinations of unsaturated polyester and glass fiber are the most common of the composites. Two composites for which demand is expected to grow especially rapidly are the combination of polymers with carbon or with aramid fibers,

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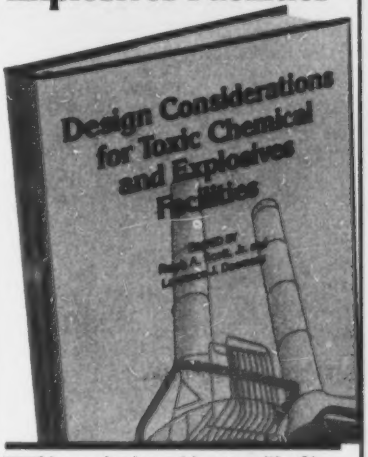
Design Considerations for Toxic Chemical and Explosives Facilities



This new book provides a wealth of information on how to protect workers and property from the hazards present in toxic chemical and explosives facilities. You'll find an excellent assessment of possible hazards, with particular emphasis on blast pressure, fragmentation, thermal parameters, and toxic chemical exposures. The editors have included practical examples and protection principles dealing with practices, training, site selection, quantity–distance separation, downwind hazard-prediction models, storage methods, and disposal. You'll read specific design consideration examples, such as:

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- intrinsically safe electrical circuits
- static charge neutralization
- operational shields and pipeline cleaning

This volume is a must-have reference for anyone who designs or works with toxic chemicals and explosives facilities.

Developed from a symposium sponsored by the Division of Chemical Health and Safety of the American Chemical Society

Ralph A. Scott, Jr. *Editor, Defense Explosives Safety Board*

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Polyethylene, polystyrene are used to package variety of consumer products

and the coextrusion of two films of plastic.

One area where development work has recently begun is in recyling or reuse of plastics. Previously, such work was mostly concerned with handling waste from fabrication operations. A growing number of companies now are recycling plastic products, predominantly bottles made of PET and high-density polyethylene that are used initially for carbonated beverages, milk, and juices. Development work on recycling is being done on a large scale at the Center for Plastics Recycling Research located at Rutgers University, New Brunswick, N.J. The center is partly financed by the Plastics Recycling Foundation, an organization supported by various manufacturers of resins, processing machinery, and plastic products. It also is supported by packagers who use plastic products and by SPI. Several government agencies, including the National Science Foundation, provide additional financing.

The need to recycle plastics is a highly visible part of the whole solid waste problem that is regarded with increasing concern by state and local authorities. Chem Systems cites an Environmental Protection Agency study in which plastics are estimated to reach 9.8% by weight of total municipal wastes by the year 2000. State legislatures and Congress are addressing the problem of plastics disposal in oceans and other bodies of water where they damage marine life. Problems of disposal, recycling, or otherwise handling unwanted plastic products, likely will remain a constant and major issue in the industry.

Despite those problems, however, use of plastics almost certainly will continue to grow. Indeed, this innovative material—which has become pervasive during the 20th century—stands to enter the next century with a full head of steam. □

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